MANUAL

OF

TELEGRAPHY,

DESIGNED FOR BEGINNERS.

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POUGHKEEPSIE.

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INTRODUCTORY REMARKS.

Although the principal design of this work is to instruct in the art of *reading by sound*, yet those who desire to acquire the faculty of reading from paper, will find the instructions equally well suited to their wants, it being impossible to give directions adapted to sound reading which are not applicable to reading by sight; indeed, every one pursuing the latter method is, in reality, governed quite as much by the clicks of the register, as by the impression which it makes.

The system of instruction adopted in the first part is the result of close and long continued observation. It not only tells the student precisely *how* to proceed in the formation of nearly every character, but, in showing the right way, depends much on pointing out to him, *where* and *how* he is likely to fail. Like observation has also made it clear that the Morse characters should never be placed before the student in alphabetical order. This part is intended to be practiced and mastered as fast as read.

The second part, in setting forth the construction of a telegraph line and the principles on which it is operated, although drawing to some extent on the imagination, aims to instruct synthetically by commencing with the fundamental principles of electro-magnets, and explaining addition after addition until a full line is pictured, as well as the various obstacles arising to impede or interrupt its workings. History and theory are entirely discarded, the present condition of the telegraph and the known principles on which its working depends, being all that is valuable to the student. This portion may be studied in connection with the writing exercises, and it should be reviewed a number of times.

While it is believed that the student, in following the line of instruction as herein laid before him, will progress more rapidly then by the adoption of any other mode of proceedure, he is

warned against falling into the too common error of expecting great results from little labor. There is no duty of a telegraphist which any person of ordinary abilities may not readily learn to perform, if he will but bestow the attention which he should willingly give to any undertaking. Students with a clear understanding of the customs and principles set forth in these instructions, and able to copy each other's telegraphic writing by sound at the rate of thirty-five words per minute, may consider themselves *operators.*

PART I.

Instructions in Manipulation and Business Forms.

Morse Characters,

L or cipher	T	E	I	S	H	P	6	A
———	—	·	··	···	····	·····	·····	·—

U	V	4	N	D	B	8	F
··—	···—	····—	—·	—··	—···	—····	·—·

Comma	Semicolon	Quotation	X	W	1
·—·—	·—·—·	·—··—·	·—·—·	·——	·———·

Parenthesis	Q	2	Period	3	M
·—··—·	··—·	··—··	·—·—·—	···—·	——

G	7	5	Exclamation	Paragraph	9
——·	——··	———	———·	—————	—··—

Interrogation	Italics	K	J	O	R	&
··—·—·	—·—·—	—·—	—·—·	··	·—·	·—···

C	Z	Y
—·—·	——··	—·——

These characters, forty-five in number, are formed of three simple elementary marks, the dot, the short dash, and the long dash. These elements, uncombined, are respectively E. T, and L, or cipher. The remaining forty-two are made up of the dot and the short dash, the long dash never being used in combination, nor repeated except to repeat the letter or figure which it represents. The original intention was to use a longer dash for the cipher than for the letter L, but practice has made no difference in them, the long dash being invariably translated

according to its connection. As an initial, or when joined with letters, it is always L: when found among figures, it is necessarily a cipher.

Six of the symbols, C, O, R, Y, Z, and &, contain, each, a *space*, the shorter separation of the elements being denominated *breaks*. The latter are only long enough to make the elements distinct from one another: the former occupies about the room that do a dot and a break.

It is well for every operator to be familiar with all of the characters in the preceding table, though some of the punctuation marks are not in general use, and on some lines hardly known. A careful examination of their formation is all that is necessary before commencing to practice them, as they can generally be committed to memory sooner than they can be made with the key.

Marks of quotation, parenthesis, or italics, are placed both before and after the word or words affected by their use.

The main points to be acquired as a basis for the whole, are embraced in the following six principles, which are to be mastered before any attempt is made to form other characters:

First principle,	Dots close together.
Second "	Dashes close together.
Third "	Lone dots.
Fourth "	Lone dashes.
Fifth "	A dot with a dash closely following.
Sixth "	A dash closely followed by a dot.

Position and Movement of the Hand.

Place the first two fingers on the top of the button of the key, with the thumb partly beneath it, thus forming a gentle grasp on the button. Let the fingers resting on it be considerably bent, so that the thumb will not slip from the under side, and the wrist and arm be entirely clear of the table. The wrist must be perfectly limber, and no stiffness should be given to

any part of the hand. No exertion is to be made with the thumb and fingers, other than in grasping the key, and from this they should not be permitted to fly during manipulation. They borrow their force from the hand and wrist, which should move directly up and down through a distance of about three quarters of an inch. The motion, both up and down, must be *free* and *full*, and of moderate firmness. A large majority of students write with much too little force; and they are inclined to limit the amount of movement, holding the lever down when it should rise, and keeping it up when they should press it down.

Avoid the error of pressing down with the fingers while the wrist is thrown up, and vice versa. The wrist, hand, fingers and key, should move in the same direction.

Remembering that the downward movement produces sounds corresponding with dots and dashes, and the upward motion the sounds representing breaks and spaces, the student may proceed with the *first principle*, making a series of dots at the rate of four or five a second, or as fast as a detached lever watch ticks. No attempt to increase this speed should be made until the whole alphabet can be readily formed, when the rate can be gradually accelerated thirty or forty per cent. Fifty per cent increase makes very rapid manipulation. Some will find it necessary to write even more moderately; and no one should manipulate more rapidly than he can do it well. The series of dots should be drilled on until the raps sound as regular as if made by clock-work.

The *second principle* may be started at the rate of one dash to a second of time, and slowly increased to three. Though uniformity in the acceleration of stroke is here desired, the important end to be attained is, a close proximity of the dashes: *breaks*, and not *spaces*, being wanted between them. In this exercise the rule is to hold the lever down: the exception being, to allow an upward *flash* of the hand, bringing the key down again in the shortest possible time. If the upward motion be *full*, it is impossible for the most rapid operator to make his marks, whether dots or dashes, too near each other where a regular space is not required. It must be continually borne in mind, that every character not containing a *space*,

must be *compact*, and not open and disjointed, so as to entirely change the meaning by a division of one character into two or more shorter ones.

In commencing the *third principle*, the student will be assisted by the knowledge that nearly every first attempt at making a single dot, produces a short dash. A quick, but firm downward flash of the key, will form a good letter E. The hand should no sooner start downward than it is quickly raised, as if the first movement were a mistake. This principle holds true in every case where a *space* follows a dot.

In drilling on this or any other character, it should not be repeated too rapidly; nor should the thumb and fingers be taken from the key during the short intervals, but through every space the thumb should pull up gently on the key; during manipulation there must always be either an upward or a downward pressure exerted.

The *fourth principle*, T, L and cipher, requires quite as much care as the letter E. An untrained hand sometimes makes T too short, but it is rather inclined to the other extreme, especially when writing words; and it, almost without exception, fails to make L, or cipher of sufficient length: indeed, both are so varied that in not a few cases, students will be found making L shorter than T.

The time consumed in making the short dash is about equal to that occupied in pronouncing the word *tea*. For L, double the time must be given, or about one second. It better be made much longer than is necessary, than a little too short, for in the former case it cannot be misinterpreted.

A dot with a dash closely following, or the *fifth principle*, is executed by giving the key one flash and one moderately slow closing, the hand going with a bound from the dot to the dash. The pronunciation of the word *again*, with the second syllable strongly accented, furnishes very correct time for the letter A. At the start, most every one finds himself inclined to make the dot too long and the dash too short, but more particularly to separate them too much.

The *sixth principle*, a dash closely followed by a dot, is one of the most difficult combinations. The tendency of the unprac-

ticed to shorten the dash and lengthen the dot, is so great, that they are frequently reversed, forming A. This, however, can generally be remedied much sooner than they can be brought near enough together.

Measuring the time for the dash as correctly as possible, for the dot the hand must give a quick flash, as if it were trying to place the dot on top of the dash. The student must not think of taking his hand up from the dash before beginning the dot; that is, the downward position of the key is to be taken as the starting point of the dot.

A strict observance of this rule will alone prevent the occurrence of a space after the dash.

Timing by the pronunciation of the word *story*, dwelling on the first syllable rather longer than usual and clipping the last very short, may prove to be good assistance. No more time should elapse between the dash and the dot than separates the two syllables of *story* in its pronunciation.

Justice having been done the six fundamental principles, the following exercises may be taken up in regular order, each character to be made many times before the next is practiced.

EXERCISE I.

E	I	S	H	P	6
.	..	...	....	.....	..... .

After practicing these separately until the right number of dots can be made, and the last dot in each character as short as the others, run them forward and backward several times, making each one but once before proceeding to the next.

EXERCISE II

A	U	V	4
.—	..—	...—	....—

In this exercise be particularly cautious to leave no space between the dots and the dash. This is the only error likely to be made. Let the dash follow the dots just as closely as if it were itself a dot.

It should be observed that this exercise is merely prolonging the last dot in I, S, H and P.

EXERCISE III.

I	A	S	U	H	V	P	4
··	·—	···	··—	····	···—	·····	····—

These are to be produced in couples as represented, but no letter is to be made twice in succession. The object is to make and readily detect the difference in those in the same couple, on account of their similarity.

EXERCISE IV.

N	D	B	8
—·	—··	—···	—····

Directions for the formation of N have already been given. It is only necessary to remember that the dots must be started from the depressed position of the hand; and that the last dot in each must be made by a movement seemingly quicker than that required for the others.

EXERCISE V.

A	Comma	F	Semicolon
·—	·—·—·	··—·	·—·—·—
X	**W**	**1**	**Parenthesis**
·——··	·———	·———·	·—·—·—

Each of these, it will be seen, commences with A; and care should be taken to begin them accordingly. The comma and quotation, being nothing more than A's close together, should be made without difficulty. F is probably as difficult as any character in this exercise. A and N must be thought of at nearly the same instant. It may be commenced with the dash much too long, in order to get the dots placed near enough to it, and then the dash may be gradually shortened until it becomes of proper length.

The semicolon can be referred to A and F, or comma and E

closely united. X is likely to be separated into A I, or more frequently into E D.

In forming W and 1, care must not only be taken to have them compact, but to get the dashes of equal length. The general tendency is to make the last one too short, and, not in these alone, but wherever two or more dashes occur together.

There seems to be no better rule for the parenthesis than to put A and U close together.

EXERCISE VI.

U	Q	2	Period	3
..—	..—.	..—..	..—.—..	...—.

The warnings already given, should make these characters comparatively easy, as they differ from some in exercise V, only in starting with a dot or two more. V and E, closely joined, will form 3; and U D will make period, when properly put together.

EXERCISE VII.

M	G	7	5	Exclamation
——	——.	——..	———	——.—

Paragraph ——.—.

The breaks in these, as made by the young operator, are seldom short enough, and the last dash, as before remarked, hardly long enough.

7 must not be turned into M I or M A, as is many times done.

EXERCISE VIII.

9	Interrogation	Italics	K	J
—..—	—..—.	—...—	—.—	—.—.

If any difficulty is experienced with 9, it should be formed from T U, or D T, accordingly as the student may be oppositely inclined to divide it.

Any other guide seems unnecessary for the next two characters. J and K are generally more difficult of formation than any of the other characters, ninety-nine persons in one hundred insisting on dividing the one into double N, and the other into N T. K should always be practiced before J, and by closely following T with A, the movement for the latter being uppermost in the mind.

After the K motion is firmly fixed in the hand and mind, J may be produced by simply adding one dot, extreme caution being taken not to change the second dash into a dot and space forming D E.

EXERCISE IX.

O	R	&	C	Z	Y
- -	- - -	- - - -	- - -	- - - -	- - - -

These can only be referred to E I and S, of which they are made. The spacing should be just sufficient to easily show that they are not intended for I, S and H. The tendency is, to open them too much, or make a dash of the dot immediately preceding the space.

EXERCISE X.

When all the characters have been correctly made, according to the preceding exercises and accompanying directions, they may then be practiced in alphabetical order, but not before. For this reason they do not appear alphabetically anywhere in this book. The very common desire to begin making them in this order, and to write one's own name even before the letters composing it have been tried separately, is altogether wrong, and should never be indulged in.

From this time onward, the student should continually bear in mind, that unless he is on the alert, he will be making heavy dots just before spaces, separating dots from dashes, but more especially dashes from dashes, and making T's too long and L's *much* too short. There are, however, certain combinations of letters in which some of these tendencies are reversed. Thus,

a difficulty is found in getting the dash in 8 near the dots, and yet the same individual, in writing *th*, finds it too convenient to join them into the figure which he is inclined to separate. The same is true in regard to *an* and figure 1, *me* and G, N and *te*, D and *ti*. There is also a strong inclination to join A, or a lone dot, to the last end of T and L, more particularly the latter.

Unitormity of space between letters, and between words also, is of no less importance than correct proportion of the letters themselves. The distance between two adjacent letters should be about great enough to accommodate one dot, though some operators place them still nearer. Double this space is to be left between words. A very common fault of young operators is to run their words too closely together; a fault which causes more trouble in reading than any other *one* feature of poor manipulation.

To the rule for spacing letters, there are two exceptions.

Double E must contain a space nearly as great as that between words.

Double L, or two or more ciphers, need not be spaced, and they usually are not. If properly made, they cannot be mistaken for anything else, as no *one* character is formed of two or more long marks.

The words *let*, *tell*, *little*, *take*, *lake* and *train*, will furnish good exercise for overcoming some wrong and strong tendencies.

When more than three figures are used to express a whole number, they should be divided into periods of three figures each, as in ordinary notation; the periods being spaced from each other the same as words. Thus: 1,250,095 in telegraphic writing will be -———- ---—-- ———— ———— —-—— ————

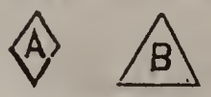
In fractions, one dot is made to represent the line between the numerator and the denominator.

1-2 is thus expressed: -———- . ---—--

7-8 " " " ———-- . —-----

4 3-5 " " " ----— ----—- . ———

No sign for dollars or cents is employed, consequently these words must be written out in full. Indeed, nothing can be telegraphed which cannot be spelled. Some private marks as those used on boxes of goods can, in substance, be transmitted by substituting for them words expressing their shape.



may be sent, *diamond* A, *triangle* B, *square* C.

When the directions thus far have been thoroughly executed, and the figures have become as familiar as the letters, most any short words may be taken up and written without a copy to be looked at. In learning to telegraph, the fault of going over a great deal and doing nothing well, is a universal one. In writing from memory, less ground is likely to be poorly run over, and one learns to send and spell at the same time, which, at first, is rather difficult.

As one cannot learn to read by sound from his own writing, he always knowing what is intended to be made, two persons must practice together, taking turns at reading and writing, and each correcting the faults of the other.

At first the characters must be learned separately, then short words chosen and written slowly and very distinctly, and well spaced. It is impossible to give much instruction that will assist in recognizing the different sounds, but there is one point to be noted. The lever makes a sound at each movement, the downward motion producing the heavier one, or that representing dots and dashes; or, more properly, the heavy stroke indicates the commencement of a dot or a dash, and the lighter sound shows when the mark ceases. E makes just as much noise as does L, the only difference being in the length of time between the heavy and the light sounds, L having no sound except at the ends. Then, if the recoil or lighter vibration be dispensed with, E, T, and L, will all sound alike. Strict attention must be paid to this fact in all the letters having spaces in them, in order that they may not be confounded with the letters which they would form, if the dot immediately preceding the space were changed to a dash, filling up the space.

Thus, compare well the sounds of O and N, R and D, C and F, & and B, Z and Q, Y and X.

Messages.

The form of regular dispatches differs but little from that of letters. Each is first dated, then addressed to some party, next comes the information to be communicated, followed by the name of the person writing it.

The terms applied to the different portions of a telegram are *date*, *address*, *body*, *signature* and *check;* and this is the order in which a dispatch is written and sent over a line.

The check is the number of words in the body of the message and the price of transmission.

What the party sending a message says to the party addressed, or all that occurs between the address and the signature, constitutes the body; and this alone is counted and charged for, unless there are more distinct signatures than one, in which case, all but the last signature is counted. Any number of names, however, constituting one firm, is to be regarded as but one signature.

Telegrams should contain as few words as possible and at the same time clearly convey the meaning intended. The use of "Dear Sir" "Yours &c.," is entirely unnecessary and seldom indulged in, as they must be considered a part of the body of the message.

Notwithstanding the adoption, by leading telegraph companies, of certain rules for counting, there is not, at the present time, any uniformity in the reckoning of compound words. It was the design of these companies to have most compound words counted *one* word for the whole compound, but the customs of operators have made the exception a better guide than the rule.

To-day, *to-night* and *to-morrow* are, each, *one* word.

Excepting A. M. and P. M., meaning forenoon and afternoon, (which are called one word each,) every initial is counted a word. F. O. B. and C. O. D., signifying *free on board* and *collect on delivery*, are three words each. Custom has made two words of such numbers as twenty-six, forty-eight, seventy-two &c.

No abbreviations are permitted in the body of a message, and all numbers are first spelled out in full, and afterwards repeated in figures; the words, and not the figures, being counted.

When desired, a company will insure the correct transmission of a dispatch for a tariff fifty per cent higher than the usual rate, in which case, it is repeated back to the operator first sending it, and he compares the repetition with the original copy.

Some lines have also doubled their rates on a certain kind of commercial dispatch, called *cipher* message. The body of these is made up of disjointed words, apparently conveying no idea, and is intended to be understood only by the party addressed.

There is but one *method* of charging for messages; ten words always being the greatest number that can be sent for the least money. Any number less than ten, costs the same as ten, but each word in excess of that number is subject to a certain additional charge. The *rates* on different lines, and for different distances on the same line vary, but the *system* of charging is precisely the same throughout this country.

If two or more copies of one dispatch are delivered to different parties, each copy must be paid for at the full rate.

Agents frequently send the same thing to five or six persons or firms.

The charges on a telegram going over any number of lines, are *all* paid in advance, or *all* collected on delivery. As dispatches themselves are valueless to a telegraph company, prepayment is usually required; but when it is known that the party addressed can be found, and the charges collected of him, a message is sent *collect*.

CORRECT FORM OF ORDINARY TELEGRAMS.

BUFFALO, May 9th 1865.

To FISHER & HAMILTON,

NEW YORK.

Send Thirty-five (35) gross at seven three eighths (7⅜.) Funds to morrow.

T. M. LONG.

10. 75, Pd

The operator sending has to insert the abbreviations "Fr" (from) and "Sig," (signature.) With "Fr," he starts to write the dispatch, and at the end of the body, "Sig." is introduced as a warning to the operator receiving, that he may place the signature in its proper position. *These abbreviations, or the words they represent, are never copied by the receiver.*

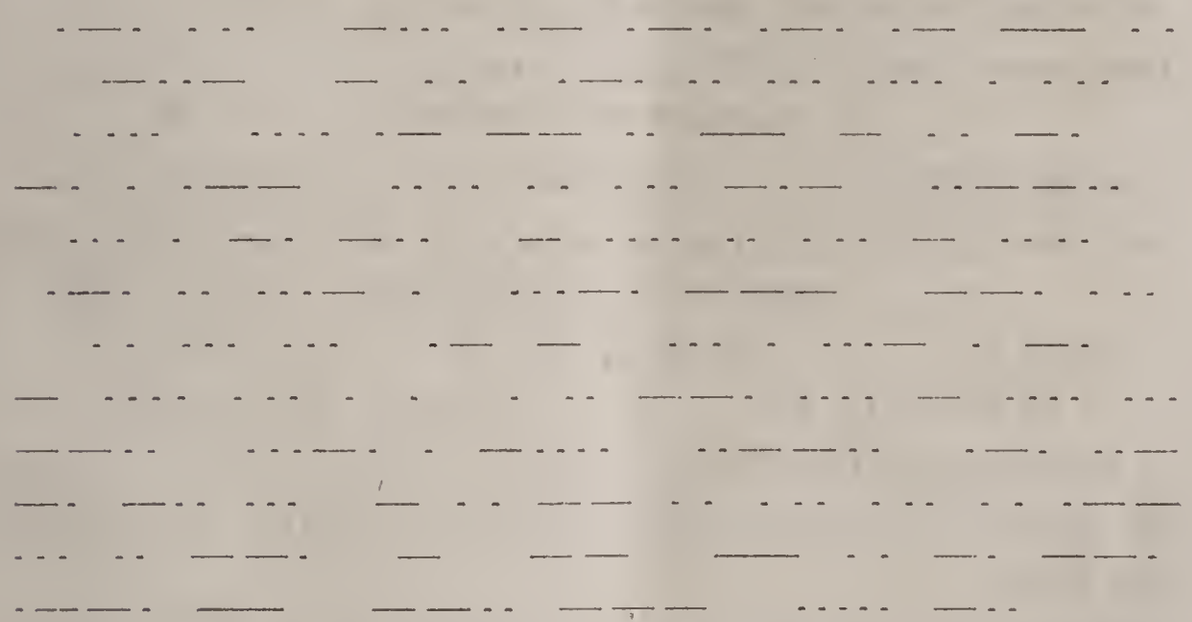
The month and year of the date are never sent over the line, and sometimes the *day* of the month is not, when it is transmitted the same day on which it is written. If written or handed into the office a day or more before sent, the correct date is telegraphed.

When the party sending requests the hour and minute of the date to be transmitted, the request is complied with.

A period should always be used at the end of the address, and at the close of every complete sentence except just before the signature. It is never placed after initials, and no kind of punctuation is made use of except at the end of the address, and in the body of the dispatch.

Many operators punctuate only with the period, scarcely knowing the shorter pauses.

The foregoing message should therefore be thus written on the line :



The check (Ck.) 10 75 Pd. (paid,) signifies that there are ten words in the message, and that the price of transmission is 75 cents, (the amount always being stated in cents,) the abbreviation "Pd." showing that the dispatch is *prepaid.* "Col." ac-

companies some checks, indicating that the charges are to be collected of the party to whom the message is addressed.

When "Pa" is found in a check, it is an order to pay out the amount following it, usually to a connecting line, but sometimes to the messenger for delivering the message some distance from the telegraph office.

There are several forms of checks having one signification, but they can be easily understood by remembering that the check of every dispatch which is *not prepaid*, must contain the term *Col.* ; and that the *absence* of *Col.* always determines prepayment, even if *Pd.* does not accompany the check.

In the following forms, all which appear in the same group are of like import.

CHECKS FOR PREPAID DISPATCHES GOING OVER BUT ONE COMPANY'S LINE.

10 50 10 50 Pd 10 Pd 50
10 N Y 50 Pd

The last form, in use on some lines, is to place before the amount the "call" of the office which receives the charges, whether prepaid or not, and after the amount to state if *Pd.* or *Col.* It will be seen that in this form, the letters, both before and after the amount, decide the place of payment.

CHECKS FOR DISPATCHES GOING OVER BUT ONE LINE, AND TO BE PAID ON DELIVERY.

10 Col 50 10 50 Col 10 N Y 50 Col.

CHECKS FOR MESSAGES GOING OVER TWO OR MORE LINES, AND INDICATING PREPAYMENT.

10 90 40 10 90 Pa 40
10 Pd 90 Pa 40 10 N Y 50 & 40 Pd

Each of these four forms means that 90 is the total charge, 50 of it belonging to the first company, and 40 to the connecting line.

CHECKS FOR DISPATCHES GOING OVER TWO OR MORE LINES, CHARGES TO BE PAID AT THE DESTINATION.

10 Col 90 Pd 40 10 N Y Col 90 Pd 40
10 N Y 50 & 40 Col

These forms show that the company delivering the message,

collects of the address 90, keeps 50 of it, and pays 40 to the line connecting with it.

Where a dispatch goes over several lines, and it is prepaid, two amounts are used in the check until it passes over the last line, when it is reduced to its simplest form—one amount: when *collect* over a number of lines, one amount is used in the first check, and two amounts in all of the rest.

The form 10 90 Pa 40, orders to be paid to the next line, all that does not belong to the line sending. Thus if a message of 10 words goes over four different lines, the charge on each of which is 25, the check will be on the

First line 10 100 Pa 75
Second " 10 75 Pa 50
Third " 10 50 Pa 25
Fourth " 10 25

In using the form 10. N. Y. 50 & 40. Pd., each line keeps its own rate separate in the first amount, the second being the tariff for the remainder of the route, whether one or several companies.

Thus, for four lines, each charging 25, we have:

First line 10 A 25 & 75 Pd
Second " 10 B 25 & 50 Pd
Third " 10 C 25 & 25 Pd
Fourth " 10 D 25 Pd

The first form of check for a *collect* message going over four lines at 25 each, gives:

First line 10 Col. 25
Second " 10 Col. 50 Pd 25
Third " 10 Col. 75 Pd 50
Fourth " 10 Col. 100 Pd 75

The last style under like circumstances produces:

First line 10 A 25 Col.
Second " 10 B 25 & 25 Col
Third " 10 C 25 & 50 Col
Fourth " 10 D 25 & 75 Col

The first company sending a *collect* message, receives its charges from the second company; the second collects from the third, the rate of the first added to its own; from the fourth,

the third receives the charges over the first three lines, and so on until the last company, on delivering the message, collects from the party addressed, the full amount for transmission.

On a *free* message, in place of the check, is sent "D H," signifying "Dead Head" or *no charge.* Sometimes the number of words in D H messages is sent the same as in paid dispatches, but in many instances, as on railroad lines, where it is well understood what communications should be *free*, even the D H is omitted.

FORM OF CIPHER DISPATCH AS USED ON MILITARY TELEGRAPHS, OR BY SPECULATORS, TO RENDER IT UNINTELLIGIBLE TO ALL EXCEPT THE PARTY ADDRESSED.

Boston, March 18th, 1865.

To Brown, Henderson & Co.,

Hartford, Ct.

Aloud rampant honor deal boots bang bag cut order fox.

Whipple & Stearns.

10 30 Pd

FORM OF DISPATCHES BETWEEN OFFICES CORRECTING ERRORS, OR MAKING INQUIRIES RELATING TO THE BUSINESS OF THE LINE.

These are known as *Ofs.* (office) *messages*, and are, of course, D. H.

To Chicago Ofs.

Can't find Hawley & Jones., 25 Fulton St. message 18th signed Peterson. Give better address.

New York Ofs.

REPLY.

To New York Ofs.

Find Hawley & Jones 75 Fulton St., not 25. Hurry answer.

Chicago Ofs.

To understand more particularly the method of sending and receiving dispatches, it must be known that every office has a *call*, which is usually one or two of the letters occurring in the name of the place, but in a few instances a letter not to be found in the name, or a figure, is used. The calls are the signals made use of in arresting the attention of the different stations as desired; therefore, all offices on the same line, or at

least all that communicate directly with one another, must have different signals. Operators must in all cases be able to distinguish their own *calls* by sound.

One office desiring to communicate with another, makes the call of that station three or four times, then gives his own office signal; and keeps repeating this until he receives a reply or gets tired of calling.

An office answering a call, makes the letter I two or three times, more or less, and then its own call.

An acknowledgment of the receipt of any kind of communication, is made by returning O K, followed by the call of the office receiving the communication.

Writing one's own office call is termed *signing;* and this must be done *once*, and *only* once, at the close of everything that is written over a line, be it calling, answering calls, giving O K, sending messages, or conversing.

Let N. Y. be the call for New York, and B that for Boston, and the New York operator will call the attention of the Boston operator, thus:

— · · · — · · · — · · · — · — · · · — · · · — · · · — · · · — · — · · · —

Boston, in reply, says: — · · — · · — · · — · · ·

When Boston calls New York, these signals merely change places.

In acknowledging the receipt of a dispatch, Boston replies with — · — · — — · · ·, or sometimes precedes the O K with the letter I a few times.

No communication is ever sent until the office to receive it has been called, and a reply has been returned; and no message is ever regarded as transmitted, until the office receiving gives O K, or commences to send back other dispatches.

Some lines number all of their messages which are not D H, each office commencing in the morning, or whenever its day's business begins, (sometimes six P. M.,) with No. 1 for each message having a destination different from others, then putting No 2 on the next one going to the same place, and so on; so that no two messages sent to the same office from any *one* place in one day, will have the same number on them. If an

office sends 20 messages to one station in one day, the numbers will run from 1 up to 20. If 20 dispatches go to 20 offices, one to each, all of them will bear No 1. The loss of a communication is much less likely to occur when it is thus marked. In transmitting messages thus numbered, the number is the first thing that is sent: "Fr" comes directly after it.

When an operator discovers that he makes a telegraphic character wrong, he corrects himself by re-writing the word in which the error occurs, and, it he sends a wrong word and detects his mistake, he says, "Msk" (mistake,) and goes back to the word preceding.

It is the duty of every operator to count the number of words in the body of every message he receives, and, if his counting does not agree with the number sent over the line, to immediately inform the sender of the fact, by stating how many words he has received. The operator sending, then counts his copy also, and, if he finds that there has been a miscount of the original message, and that the operator receiving has the right number, he corrects his check; but if he sees that the words are correctly counted, he begins to repeat the body of the message, and proceeds until the operator receiving discovers the error. Sometimes the initials only are repeated. The main object of counting messages in offices receiving them, is to avoid incorrect transmission.

If, while receiving anything over a line, an operator for any reason does not get it satisfactorily, he at once calls for a repetition of the unintelligible part by using some abbreviation meaning "go ahead" or "start at," and writing the last word which he gets perfectly.

The operator receiving a dispatch should always mark on the blank, in a place provided for that purpose, the hour and minute of its reception, and the one sending must put on the face of his copy, in some convenient place, the hour and minute at which he sends it, and sometimes also the initials of both sender and receiver, and the name or number of the wire on which it is sent. Some offices mark on one corner of original messages, the time at which they are received from the public.

Abbreviations

Are used in conversation, news reports, office and other D H messages, and about *paid* messages, but never in the *body* of them. The number of abbreviations in use on the various lines is quite large, but those which are used alike by all, are comparatively few. Numerical abbreviations differ so greatly in their meaning on different lines, that it is deemed best not to lumber the student with information which he may have to unlearn.

The following list, including those which have one signification on all lines, will give the student such a start that he can easily learn others from their connection:

Abv.	Above.	Cm.	Come.
Ads.	Address.	Co.	Company.
Ae.	Are.	Cmn.	Common.
Af.	After.	Com.	Communication.
Ay.	Any.	Condr.	Conductor.
Abt.	About.	Chgs.	Charges.
Agn.	Again.	Dd.	Did.
Ahr.	Another.	Dg.	Doing.
Amt.	Amount.	D. H.	Free.
Ans.	Answer.	Dn.	Done.
B.	Be.	Ds.	Does.
Bf.	Before.	Dw.	Down.
Bk.	Back. Book.	E.	Of the.
Bn.	Been.	Eh	Each.
Bat.	Battery.	Ehr.	Either.
Bbl.	Barrel.	Ex.	Express.
Brk.	Break.	F.	Of.
Btn.	Between.	Fi.	Fire.
Btr.	Better.	Fr.	From.
Bsns.	Business.	Frt.	Freight.
C.	Can.	Fwd.	Forward.
Cc.	Commence.	Fig.	Figure.
Cur.	Current.	Guar.	Guaranteed.
Col.	Collect.	G. A.	Go ahead.
Cd.	Could.	Gd.	Good.
Ci.	Circuit.	Gg.	Going.
Ck.	Check.	Gi.	Give.

G. M.	Good Morning.
Gn.	Gone. Good Night.
G.	Ground.
H.	Have.
Ha.	Has.
Hd.	Had.
Hf.	Half.
Hm.	Him.
Ho.	Who.
Hr.	Hear. Here.
Hs.	His.
Hu.	House.
Hw.	How.
Hy.	Heavy.
Htl.	Hotel.
Ik.	Like.
Immy.	Immediately.
Inst.	Instrument. Instant.
Impsb.	Impossible.
Impt.	Important.
K.	Take.
Kg.	Taking.
Kn.	Taken.
Kp.	Keep.
Kps.	Compliments.
Kw.	Know.
Lv.	Leave.
Lrn.	Learn.
Ltr.	Letter.
Ltl.	Little.
Ma.	May.
Md.	Made.
Mk.	Make
Mkg.	Making.
Mh.	Much.
Mr.	More. Mister.
Mt.	Meet.
Mv.	Move.
Min.	Minute.
Msk.	Mistake.
Mtr.	Matter.
Msg.	Message.
Msngr.	Messenger.
Nh.	North.
N.	Not.
Na.	Name.
Ni.	Night.
Nn.	None.
No.	Number.
Nr.	Near.
Ns.	News.
Nvr.	Never.
Nsy.	Necessary.
Ntg.	Nothing.
N. M.	No more.
O. K.	Correct.
Ovr.	Over.
Obg.	Oblige.
Ofs.	Office.
Ohr.	Other.
Opr.	Operator.
Pa.	Pay.
Pc.	Place.
Pd.	Paid.
P. O.	Post Office.
Pls.	Please.
Ppr.	Paper.
Psb.	Possible.
Qk.	Quick.
Qt.	Quite.
R.	For.
Rr.	Repeat. Railroad.
Rs.	Raise.
Rt.	Right.
Rhr.	Rather.
Rtn.	Return.
S.	Was.
Sa.	Same.
Sd.	Should. Said.
Sh.	Such.
Sl.	Shall.
Sm.	Some.
Sn.	Soon.
Su.	South.
Ss.	Says.
St.	Street.
Sfb.	Stop for breakfast.
Sfd.	" " dinner.
Sft.	" " tea.
Sfn.	" " the night.
Sig.	Signature.
Sml.	Small.

Stk.	Stock.	U.	You.
Smtg.	Something.	Ur.	Your.
Stix.	Sticks.	Ut.	But.
T.	The.	Un.	Under.
Tt.	That.	Und.	Understand.
Td.	To-day.	V.	Very.
Tff.	Tariff.	W.	Will.
Tg.	Thing.	Wa.	Way.
Ti.	Time.	Wd.	Would.
Tk.	Think.	Wh.	Which.
Tnk.	Thank.	Wi.	With. Wire.
Tm.	Them. To-morrow.	Wk.	Week. Weak.
Tn.	Then.	Wl.	Well.
Tr.	Their. There.	Wn.	When.
Ts.	This.	Wr.	Where.
Ty.	They.	Ws.	West.
Tel.	Telegraph.	Wt.	What.
Tho.	Though.	Wy.	Why.
Trn.	Train.	Whr.	Whether.
Thot.	Thought.	Wrd.	Word.
Thru.	Through.	X.	Next.

Besides the foregoing, there are several large classes of words having certain terminations, which are abbreviated in a regular manner.

The termination	ing	drops		in.
	ed	"		e.
ion or	ian	"	io or	ia.
	ive	"		ie.
	ial	"		ia.
	ble.	"		e.
	ful.	"		u.
	ess.	"		es.

PART II.

Practical Science.

General Principles of Electro-Magnetic Telegraphs.

All telegraphs effecting communication by means of magnets produced by electric currents, are styled *Electro-Magnetic ;* and in each are to be found five principal parts, as follows :

Conductors, for conveying the motive power—*Electricity*—between places more or less distant.

Insulators, to confine the electric current to the conductor.

Batteries, for producing the motive power.

Magnets with their appurtenances, to be actuated by electricity.

Manipulating keys, for controling the current.

CONDUCTORS AND INSULATORS.

To make lightning our obedient servant, we must understand that there are certain substances through which it will readily pass, while other bodies allow it to move with great difficulty, or entirely obstruct its passage. The first named are *conductors;* the others, *non-conductors* or *insulators.* In these two general classes are found many shades of difference, so that there are all degrees of conducting power from the best conductor to the best insulator. Metals and their alloys rank first as good conductors. Among the best of these are silver, tin and copper, different authorities placing different ones at the head, while iron and platinum, as regards their power of

conduction, are quite low in this class. The only non-metallic substance whose conductibility at all approaches that of the metals, is carbon well calcined. Other forms of this element, as charcoal and plumbago, conduct in a less degree, while the diamond, which is pure crystalized carbon, is a good insulator. Some acids, saline solutions, moist earth, animals and green vegetables, are conductors in a still smaller degree. Pure water is yet lower in the scale, and when frozen so as to be perfectly dry, is a non-conductor.

There is a great variety of substances having so feeble a power of conduction that they are regarded as non-conductors. Among such are chalk, lime, marble and stone generally ; rust of metals, fibrous substances, as wood when dry, leather, parchment feathers, paper, hair, wool, silk and cotton. Dry air, sulphur, resin, sealing wax, gutta percha, shellac, rubber and glass, are the best of insulators. Any substance reduced to a powder becomes a conductor to a certain extent, on account of its absorption of moisture. Frictional electricity, which is vastly more intense than galvanic, can pass through glass only by making a fracture ; hence, glass may be said to be an absolute non-conductor.

As oxides of metals can scarcely be considered conductors, all joints in a wire over which an electric current is to pass, should, when formed, be perfectly clean. In making a splice in a wire, enough of the two ends to form the joint should first be brightened, and then each wire should be firmly wound around the other, (Fig. 1,) the different revolutions touching

Fig. 1.

one another, and passing, as near as may be, at right angles with the wire which they surround. A wire in being spliced must never be bent back and wound upon itself, forming a loose loop, which, for telegraphic purposes, is very unreliable. In splicing two wires in an office, each one should be given eight or ten revolutions ; but four or five will answer for the line wire, because the strain on it always keeps those joints

firm. Splices in offices, however, should be avoided as much as possible.

It must be noted that, in order to keep a current of electricity confined to a wire over which it is wished to pass, the wire must not be permitted to touch other conductors in such a manner that the current will run off on them. This is accomplished by suspending the wire on *insulators ;* and when thus separated from other conducting bodies, it is said to be *insulated.* Glass and vulcanized rubber are the articles chiefly employed in the insulation of telegraph lines. A section of the glass insulator, and the manner in which it is attached to the pole, are exhibited in Fig. 2. B is a bracket, usually of oak, which is spiked to the pole P. Over the upper part of the bracket fits the glass G. The wooden shield S is seldom used. The line wire passes by the side of the glass to which it is fastened by a "tie" wire. The glass on the under side is concave, for the purpose of keeping that portion dry during wet weather, to prevent the current from passing from the wire to the pole.

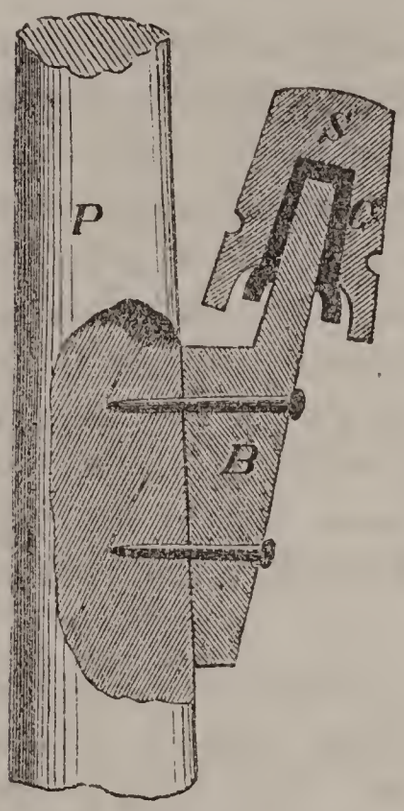


Fig. 2.

GALVANIC BATTERIES.

In the fluid of each cup of every galvanic battery, two pieces of solid conductor are placed, one end of each projecting above the fluid. These ends are termed *poles.* One of these pieces is always *zinc ;* the other, some finer metal or carbon.

A battery will generate no electricity except while some unbroken conductor is touching *both* poles, or the poles themselves are in contact with each other. The conductor, as of wire, may be of any length, and the battery will force electricity through it if the continuity be perfect : but the slightest imaginable opening in any portion of the wire will completely obstruct the

passage of any electric fluid. The flow of electricity is known under the name of *current;* while *circuit* is the term applied to the conductor or *path* for the current. The metals and fluids in the battery, as well as the wire, are to be considered a portion of the *circuit.*

An important principle to be continually borne in mind is, *that a current cannot be made to start from one pole of a battery, unless it can pass around and touch the other pole, be the distance a few inches or a thousand miles.*

There are but three kinds of batteries in general use on telegraph lines: the Grove, the Leeson, and the Daniell or blue vitriol. The last is the only one here considered, as it is the one generally, if not universally, employed at all stations where young operators are likely to be called on to take care of a battery.

The Daniell battery is usually constructed as represented in Fig. 3, in which G is a glass or glazed earthenware jar, C a cylinder of copper, open at the side and bottom, P C a porous cup, and Z a cylinder or rod of zinc.

A pocket is formed on the outer and upper side of the copper, for the purpose of holding extra crystals of blue vitriol, to keep up the strength of the solution. Sometimes an independent pocket, suspended on the glass jar, is used; and the copper is, in some instances, formed into a perfect jar, so that the glass jar is dispensed with; but such cups are liable to become leaky.

This battery thus put together, must stand several hours with closed circuit before it will acquire much strength. If a new battery of this kind is required to work as soon as set up, after placing the cups and cylinders in their proper position, the blue vitriol should be pulverized and put into the copper pocket, and then warm water (not hot enough to break the glass) filtered through it until the solution reaches within about two inches of the top of the jar. Then warm or hot water should be poured into the porous cup until the surfaces of the water and the blue vitriol solution are on a level with each other. The addition of a tablespoonful or two of the blue vitriol solution to the water in the porous cup, will cause

the battery to start off with nearly full force. Six or eight drops of sulphuric acid, half a teaspoonful of white vitriol (sulphate of zinc,) or of common salt, will answer the same purpose. This battery as generally constructed and used for local circuits, will run without any attention for ten or fifteen days, according to the length and size of the wire in the local magnet, and the number of office hours per day. If the blue vitriol solution is kept saturated, whenever the battery becomes too much weakened, the zincs must be taken out and scraped, and the water in the porous cups, with the exception of a table-spoonful or two of the clear to each cup, must be thrown out and replaced with clean water. If no reservation of the old water (solution of sulphate of zinc) be made, and nothing but pure water be used, the battery, after cleaning, will be very weak for some time. The blue vitriol solution will last a year or more, or until it becomes too filthy from external causes.

It is well for every operator to understand that blue vitriol is oxide or rust of copper, dissolved in sulphuric acid. The action of the battery separates the acid from the copper, the latter being deposited on the copper cylinder, and the former passing through the porous cup and uniting with the zinc, produces white vitriol or sulphate of zinc. Therefore, the growth of the copper in thickness, and a corresponding diminution of the zinc, are neither mysterious nor illegitimate.

Once in two or three months, the copper should be taken out, and the deposit peeled off. This may be done several times, when the deposit will adhere too firmly to the original plate to be removed. Then, when so much copper accumulates as to afford too little room for the porous cup, new coppers must be brought into service.

The porous cups also become coated with copper on the outside, which, after a while, so fills up the pores as to render the cups worthless.

Neglect to keep a surplus of blue vitriol in the pocket designed for that purpose, will allow the upper portion of that solution to become weak, and in consequence, another current (on the principle of a battery formed of one metal and two

fluids) is set up, which eats holes through the copper cylinder where the solution has become exhausted.

The blue vitriol solution, by the combined action of evaporation and absorption, creeps slowly up the sides of the jar, and runs over the top and down the outside. This feature of the Daniell battery is the greatest objection to it; and, as yet, there seems to be no remedy for it.

In this battery the copper pole is the *positive*. The zinc is the *negative* in this and every other kind of battery now in use.

In joining together any number of cups, whether of the same, or of different kinds of battery, the positive pole of the first cup must be connected with the negative of the second, the positive of the second with the negative of the third, and so on throughout the whole series. It matters not which pole we commence with, if we are only careful never to connect like poles; but this law must be as strictly observed in joining batteries hundreds of miles apart, as if they stood side by side.

No battery should be permitted to freeze, for, while frozen, the current is very much impaired, or altogether suspended. A battery while warm works more vigorously, as heat is a promoter of chemical action. The connections must be kept free from rust and dirt, in order to allow the current to pass through them freely.

MAGNETS.

A piece of metal that will attract another at a perceptible distance, and with a force greater than that of gravitation, which is a property of all matter, is a *magnet*. The number of substances susceptible of the magnetic property may be limited to five: nickel, cobalt, iron and two of its compounds. These compounds—steel (carburet of iron) and Lode-stone (an iron ore)—form *permanent* magnets. Magnets of *soft iron* are altogether used for telegraphic purposes, on account of their superior magnetic power, and the great rapidity with which they acquire and lose it. The softer the iron, the quicker its action; and therefore, for temporary magnets, it is thoroughly annealed.

If a piece of soft iron be placed near a wire, over which a current of electricity is passing, the iron, under the influence of the electric current, will be instantly magnetized, *although the two do not touch each other*, and will attract any other substance that can be similarly affected under the same influence. The moment the flow of electricity stops, the iron ceases to be a magnet; and thus it can be magnetized and de-magnetized far more rapidly than any hand can vibrate. A bar of iron can, not only become magnetic from a current not in contact with it, but can also impart this force to another piece of iron at a perceptible distance; in fact, there can be no attraction until this has taken place, when each attracts the other with the same force; hence, *magnets attract nothing but magnets, and this attraction is always mutual.* There are other means by which this peculiar property may be given to iron, but none of them have any bearing on telegraphy.

Nearly all the magnetic force of an iron bar, accumulates at the ends, which are termed *poles;* and these poles, on account of a strange difference in their action, are distinguished by *north* and *south.* A north pole always *repels* a north, the same as do two souths; but north and south always *attract* each other. One end of *every* magnet has north polarity, and the other end has that of south; hence, one pole of a magnet always attracts the other. To obtain the full power of a magnet, it must be bent in the middle, so that the ends come near each other; and then both poles may be brought to act on the same object. When a piece of soft iron is presented to the poles of a magnet, the effect of the latter on the former, is uniformly such as to set up an attraction between the two; that is, one pole cannot generate the same polarity in another piece of metal so that the two will repel each other. If, instead of bringing a rod of iron near a strait wire carrying an electric current, a long wire be completely covered with silk, or some other non-conductor, and then wound several hundred times around the iron rod, as thread is put on a spool, the magnetic effect of a given current through the wire, will be vastly augmented. The object of covering the wire with silk, (insulating it,) is to keep the different revolutions from touching one another, so as to

compel the current to follow the whole length of the conductor.

Let us take a rod of iron eight or ten inches in length, and about half an inch in diameter, and bend it into the form of the letter U; then make, of some non-conducting material, as hard rubber, two spools, each about three inches long, and the ends an inch and a quarter in diameter, and fill them with insulated copper wire. Next, slip these spools on the legs of the bent rod, join the wire of the two spools, and we shall have an electro-magnet very much like some in use on telegraph lines. Both spools should be wound in the same direction, and in joining them, both inside, or both outside ends of the wires, should be firmly twisted together, after the silk covering has been removed for a short distance, and the ends of the wires have been brightened. If one inside should be connected with one outside end, the current through one helix would neutralize the effect of the other helix, so that no magnet would be produced. In such a case, a current through either half of the wire would magnetize the iron, but not when passed through both helices.

THE KEY.

For stopping and starting the current on a wire, or, in telegraphic phrase, *opening* and *closing circuit*, instead of holding the two ends of a wire in the hands and striking them together, the key, a device for a more convenient, rapid and uniform movement, is thus arranged: A movable metallic lever, *m*, Fig. 4, on an arbor, is supported by screws in the elevated sides of a metallic base, *b*. Directly beneath *m*, is another piece of metal, *a*, which is separated from *b* by some non-conductor (usually vulcanized rubber.) On the top and in the centre of *a* is fastened a small piece of platinum wire, and directly above on the lever, *m*, is another piece of the same metal. A screw enters the base at *d*, and serves to fasten the key firmly to the table, and, at the same time, hold one end of the wire to be operated. In the same manner another one screws into *a*, to help bind the key to the table, and hold the other end of the wire. Now, as *a* is insulated from *b*, the current cannot pass from one to the other, except while *m* is pressed down, bringing togeth-

er the two platinum points, which are, in reality, the two ends of the wire. As a light spring, under *m*, is nearly always employed, keeping the platinum points separated whenever the hand leaves the key, a *circuit closer*, *c*, is added. This is a movable brass arm screwed to the base, so that it can slide under a lip on *a*, thus keeping *a* and *b* electrically connected while the key is not in use. When either *m* or *c* touches *a*, the key and circuit are said to be *closed*. *Both* must be away from *a* in order to *open* or *break* circuit. The back end of *m* is furnished with a screw for regulating the amount of movement which the lever is desired to have. The finger piece of both ever and circuit closer, is of some non-conductor, to protect the operator from receiving an electric shock from the wire to which the key is attached.

Morse System of Telegraph.

The Morse system of communication does not consist in the manner in which the line is built, nor in the kind of battery used on it, as all systems are alike in these respects; but it depends on the method of applying the current to the magnets, the appurtenances of the magnets, and the peculiar mode of causing one current to operate others.

If a magnet, such as last described, be placed in New York, and one end of the wire connected with the earth by means of some good conductor, and from the other end of the magnet wire, another one of sufficient length be extended to Washington—care being taken to have it touch nothing but insulators between the two cities—and this long wire attached to one pole of a powerful galvanic battery, the other pole of which is connected with the ground by a third wire, the iron of the magnet in New York will be very sensibly affected by the battery in Washington. If we now take a piece of iron long enough to cover the poles of the magnet, and bring it near them, we will find it to be drawn towards the magnet with a very appreciable force.

We will produce an instrument like a portion of the Morse, by fastening the magnet, *m*, Fig. 5, to a dry and finished piece of board, *b*, joining the second piece of iron, *a*, to a small brass bar, and supporting this bar on pivots also fastened to the wooden base in such a position as to bring the iron near the poles of the magnet. This iron and the brass bar to which it is attached, must be free to move towards and from the poles of the magnet. This movable portion is known as the *armature*. The distance through which the armature moves is regulated by two brass posts running up from the base, one of them checking the motion towards the magnet, and the other limiting the reverse movement; or, two adjustable screws supported by *one* post, are most frequently employed, in which case it is necessary that the point of the screw checking the back-

ward movement, be made of some insulating body. As represented in the Fig., every place to which a wire is to be attached, is furnished with a binding-screw. By attaching to the armature a light spiral spring pulling in a direction from the magnet, this portion of the instrument is made ready to note electric pulsations. The attractive power of the magnet must, however, overcome the force of the spring.

Now let the wire in Washington be broken, and the magnet in New York will instantly lose its magnetic properties, and, in consequence, the spiral spring will pull the armature back. On joining the wire again in Washington, the magnet is simultaneously charged, drawing the armature forward. If the opening and closing of the wire be done after the manner of telegraphic characters, the armature in New York will, at the same instant, click out the same letters, so that a sound operator will understand them with the greatest ease.

Such a line may be cut in Philadelphia, and the two ends thus made, be joined to another apparatus precisely as in New York, when both instruments will be alike operated, and at the same moment. In like manner and with like results, other instruments may be placed in Baltimore and Washington, and at as many intermediate points as may be desired. The wire may be opened and closed at any other station, as well as at Washington. The simultaneous working of all the magnets connected with the line will be effected by breaking and re-establishing the continuity of the wire at *any* point on the route ; and this is, as has already been anticipated, done by means of the key.

By reference to the remarks on batteries, it will be understood why the ends of the line were connected with the ground at New York and Washington. The battery was located at the latter place, and, as no current could go to New York without returning to the same battery, we either had to put up a second wire for this purpose, or allow the current to return through the earth, which proves to be better than a return wire, saying nothing of the difference in expense.

Although a battery at Washington will work a line from that place to the metropolis, a second battery at the latter city

will improve the working, and a third placed at Philadelphia might, sometimes, be an advantage. Every office, however, must have a key to send messages with, and a magnet with which to receive them.

Again ; tracing out a line from New York to Washington having four offices on it, one in each of these two cities, and also in Philadelphia and Baltimore, commencing at the earth in the first named city we find : a wire running from the earth up into the office and connecting with one pole of a galvanic battery ; then from the other pole of the battery, another wire running into one of the binding-screws of the key ; a third wire then extending from the other binding-screw of the key to one end of the wire of the magnet ; and from the other end of the magnet wire, a fourth wire running out of the building at the top of the window, and passing along the route–supported all the way on insulators fastened to poles, to keep the current from passing down to the ground—until the wire reaches Philadelphia, where it enters that office, runs through the magnet and key precisely as in New Yerk, and again emerges from the window. The passage of the line through Baltimore and Washington is nothing but a repetition of what has taken place in the first two cities. In the last named city, the line, after joining key, magnet and battery, connects with the earth, the earth joining both ends and completing the circuit.

As any *one* break anywhere in the circuit completely checks all of the current throughout the whole line, it follows that all keys must be shut except the one sending a message. Therefore, *two dispatches cannot be sent over one wire at the same time.*

All wire used within offices is of copper. Iron is used for the line wire, on account of its superior strength and greater cheapness.

It is not at all necessary to connect the different parts of the apparatus in the order just described. In passing a line through an office in which are a battery, key and magnet, it matters not in the least, which of them is the first, second or third to be connected ; the only requisite being, that they be joined one after another ; for place the key where you will in the circuit, it will do its labor of starting and stopping the entire current;

the magnet, situated at any point on the line, will be operated; and the battery will send its current over the whole line, if only properly connected at any place. Neither does it make any difference which way the current passes through the key or magnet. The reversal of the current through the magnet reverses the poles, but the polarity of the armature is likewise reversed, so that the working of the magnet remains unchanged.

All such questions as, "Does a message have to be forwarded at every office it is to pass?" "Which way does a dispatch go over a line?" and "What is the method of sending in different directions?" should be satisfactorily answered by the fact that, when a line is in a normal condition, *every* key in the same circuit, *always* operates *every* machine situated in it, at the *same instant* and in the *same manner.* *

MAIN AND LOCAL CIRCUITS.

A line of telegraph as thus far represented, is not a very efficient one; and is it not the Morse system *complete.* Although powerful batteries be used on such a line, the great resistance offered by so many miles of wire, reduces the strength of the current to such an extent, that but a weak magnet can be produced. The motion communicated to the armature of the magnet, is too feeble to properly mark paper, or to give as satisfactory a sound as can be obtained by the addition of other batteries and machines in a certain manner.

The armature of the magnet, having a motion precisely like that of the key, is converted into one, and used to operate another magnet, Fig. 6, supplied with a current from another

* It is not known whether electricity is a material substance or merely a property of matter; and any opinion as to whether its transmission be in the form of a current, by vibrations or otherwise, is sheer speculation. It is simply known that an *effect* travels with inconceivable rapidity, and seemingly in both directions.

Professor Faraday, in speaking on the nature of electricity before the British Association for the Advancement of Science, thus expressed his views: "There was a time when I thought I knew something about the matter; but the longer I live, and the more carefully I study the subject, the more convinced I am of my total ignorance of the nature of electricity."

When as great an electrician and profound a philosopher as the world has produced, arrives at such a conclusion, the student must regard all terms seeming to indicate any form or motion of electricity, as nothing more than convenient expressions.

battery, Fig. 3. To accomplish this, a battery, Fig. 3, is stationed in the office, usually quite near the instrument, and from one pole of it, a wire, *n*, is run to the bottom of the armature of the magnet already described, Fig. 5, and from the brass post which checks the armature in its motion towards the magnet; a second wire, *o*, is connected with another magnet, Fig. 6, and this magnet is, with a third wire, *d*, joined to the other pole of the battery from which the first wire was started. Thus a new and very short circuit is formed of the extra battery, the extra magnet, and the armature of the first magnet. This short, side or independent circuit, represented by red lines, is wholly confined to the office, and is called the *local circuit.* Fig. 6 is a *sounder*, or in case a *register* is used, it simply takes the place of the sounder, and is connected in the same manner. *Main circuit* is the name given to the one shown in black lines. The main circuit is the line itself, of which the earth forms one half. The batteries have the same name as the circuits to which they are attached. The map exhibits no main battery, and does not represent the different parts located *precisely* as they are to be found in an office, but it shows their exact relations, or how they are connected. The local battery is generally placed under the table on which the instruments rest, and only enough of the ends of the wires for connecting the different parts, are allowed to come up through the table.

It must be distinctly understood, that the main and the local currents *never* touch each other; and that the local exerts no influence whatever on the main. The only substances which are in contact with the two circuits, are the air and the wooden base, *b*, Fig. 5, and both of these are *non-conductors.* The armature, *a*, Fig. 5, closes the local circuit by striking the screw above the magnet. That these two points may keep bright and make a good connection, they are made of platinum the same as those of the key; but the tip of the other screw is of some non-conductor, so that the current cannot pass over it when the armature is drawn back by the spring. This armature is simply the key that operates the local circuit, and it may be moved back and forth by the finger without in the least affecting the line.

Fig. 5, represents the portion of the Morse apparatus known as the *receiving magnet*, because it is the first thing affected by the electric pulsations on the line. *Relay* is the name by which it is known among operators generally. By the map it is seen that every key and relay magnet is situated in the main circuit; and that every relay armature has a local battery and a sounder or register attached to it. The key operates the relay magnet; the relay magnet operates the armature (by attracting without touching it;) and the armature works the sounder or register in the same manner that the key affects the relay. The movement of the armature is feeble, but powerful enough to open and close the local, which, on account of the little resistance in so few feet of wire, operates the sounder with many times the force of the armature.

The binding-screws fastening the wires, *o*, *n*, to the relay, are permanently connected with the armature and post by wires beneath the base.

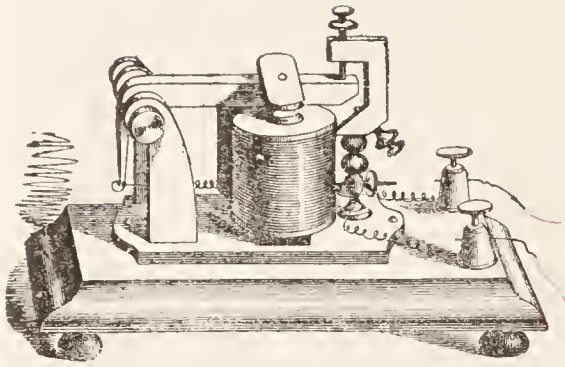


Fig. 6, Sounder.

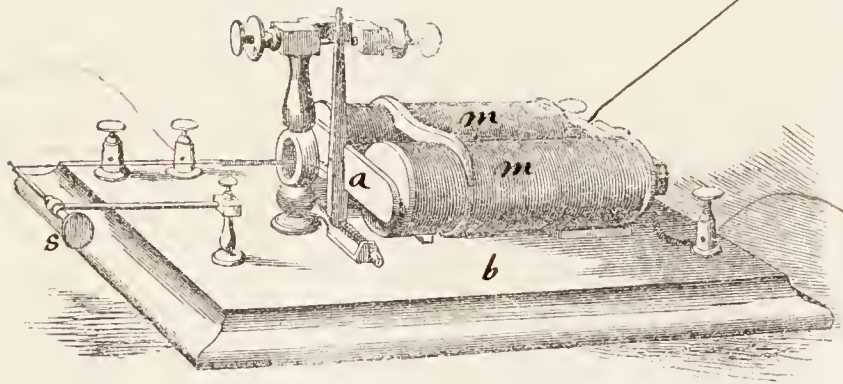


Fig. 5, Relay.

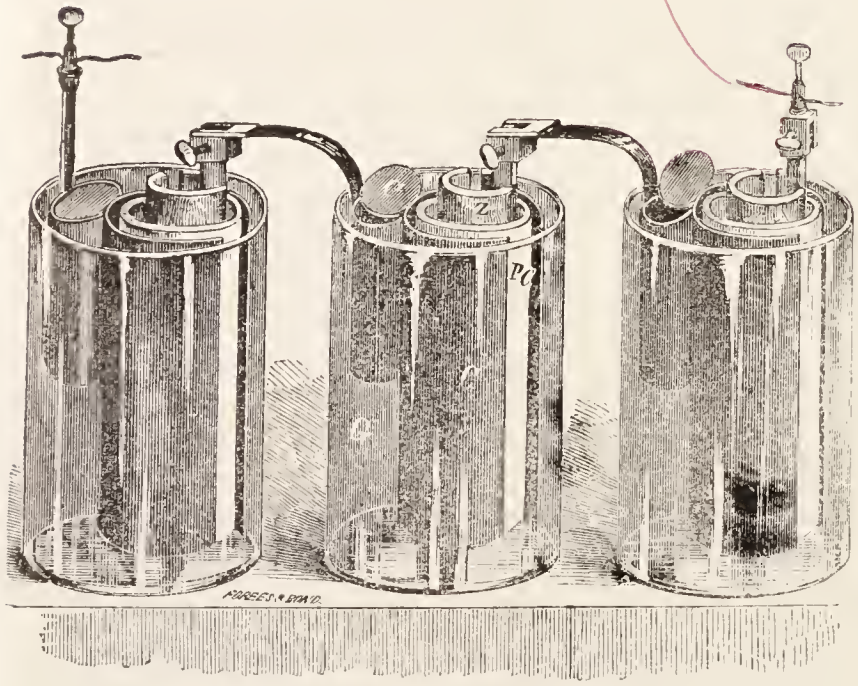


Fig. 3, Local Battery.

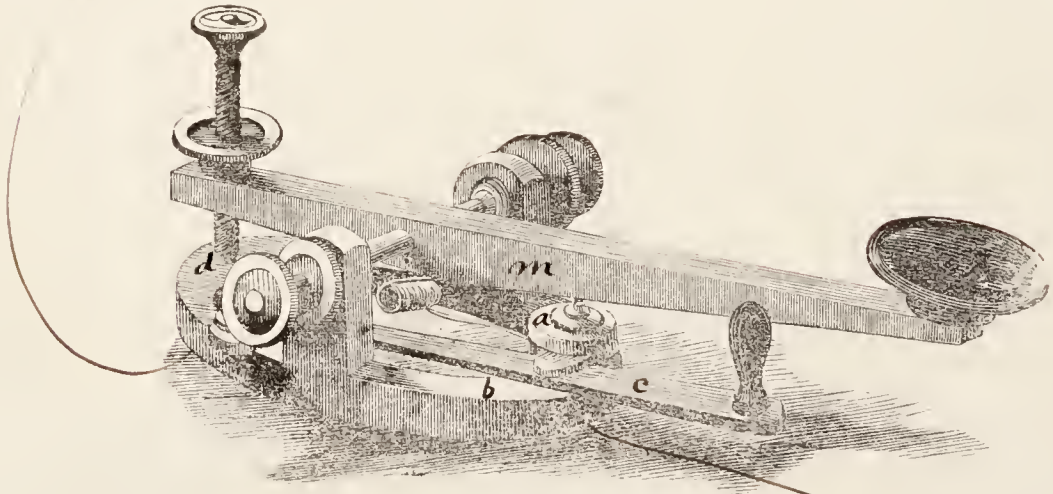


Fig. 4 Key.

Management of Instruments, Wires and Batteries.

GROUND WIRES.

If, to a line from New York to Washington having a main battery at the latter place only, some conducting substance be joined, and then connected with the earth, as at Philadelphia, the current will pass over this conductor and return to Washington, and no electricity will reach New York to operate that instrument. All machines between the conductor in question and Washington, will be worked. Such a wire is named the *ground wire;* and every intermediate office is supplied with one, to be used only in case of trouble on the line. Where gas or water pipes enter an office, the ground wire is attached to them. Stations not having this excellent means of ground connection, fasten a wire to a plate or rod of metal, and bury the piece of metal so that it is always in contact with moist earth.

If Philadelphia puts his ground wire in contact with the line south of his instrument, and there is a main battery at each end of the line, the currents from both batteries will go only to this ground wire, and passing over it, to or from the earth as the case may be, will return again to their respective batteries. During this state of things, the current from New York reaching the Philadelphia machine, these two offices can communicate with each other. The current from Washington not quite reaching the instrument at Philadelphia, does not permit the latter city to hold communication with any office south of it; but Baltimore and Washington can work together at the same time that New York and Philadelphia do. The ground wire divides the line into two independent circuits, and forms a common conductor for both currents, on the same principle that the earth forms one half of every main circuit.

BREAKS.

Let the line so break between Philadelphia and Baltimore that the ends fall on the ground, and two entirely distinct lines will be the result; and offices on the same side of the break, will work with each other as if nothing had happened. Should the southern end of the break be so near a pole as to hang in the air, the circuit south of it would be left open, and Baltimore in order to work with Washington, would have to complete the circuit with his ground wire. Should he apply it south of his instrument, the current (from Washington) would pass over the ground wire before quite reaching his machine, and his inability to work would show trouble on the line north of him.

The northern end of the break being on the earth, Philadelphia does not use his ground wire to effect communication with New York, but his inability to raise either office south of him after repeated efforts, leads him to suspect some difficulty on the line. Then by applying his ground wire north of his instrument, he finds there is no current from the Washington battery. This simply shows him that the line is in some way connected with the earth between him and Washington, probably north of Baltimore, because he cannot be raised; but it by no means proves that the wire is broken.

Should the circuit get open between the two points in an office where the ground wire is applied, no current could be made to pass through that instrument by the use of the ground wire; therefore, whenever an operator cannot get a current from either direction, he should carefully search this portion of the main circuit in his office for an opening in it.

ESCAPES.

In picturing a line and its workings thus far, it has been the supposition that when *any* of the current on a line is broken, *all* of it is; and that the entire current always goes the whole length of the line. This is what is desired, but circumstances frequently render it impossible. Returning again to the same

line, and placing a wet rope or a stick of green wood so as to touch both the line and the earth at Philadelphia, we find that only a *portion* of the current passes through the rope or wood, while the *remainder* of it follows the entire length of the line.

Now let New York open his key, and he will take from the line, all the current from his own battery, and that portion of the Washington current which does not pass over the poor conductor touching the line at Philadelphia : in other words, he will interrupt just what reaches his key. That from the south finding its way through the green wood, is still passing over the line from Philadelphia to Washington, and partially magnetizing the relays on this portion of the route, and keeping the local circuits closed when they are wanted to be open, unless the relay springs have sufficient tension to overcome the residual attraction. This leakage of the current from the line to the ground passes under the name of *escape.* Offices on the same side of an escape, can communicate with each other as usual, but it is difficult, and sometimes impossible, for an office on one side to receive writing from another station beyond the partial ground wire. Some lines are much annoyed in this manner by the interference of trees, and *all* lines are affected by rainy or foggy weather. In wet weather, every pole and insulator becomes a feeble conductor and, perhaps, the air itself, thus offering so many inducements for the current to run down to the earth, that sometimes it cannot be made to go over fifty miles from the battery and, of course, a dispatch can be sent no greater distance.

If Washington, testing an escape to determine its location, has Baltimore open his key, and then he (Washington) tries to operate his own instrument, but cannot do so—because there is no current left on that end of the line—he knows the escape to be north of Baltimore. Now if Baltimore closes his key, and the one in Philadelphia is opened, and Washington finds that he can work his own machine, or, perhaps, communicate with Baltimore, it proves an escape to exist between Baltimore and Philadelphia. Again ; if Washington finds a little current left on the line while Baltimore is open, and a still stronger one while Philadelphia has his key open, it shows an escape in two

places. To clearly understand the ill effects of escapes, it must be borne in mind, that *sending* is a systematic putting on and taking off of the current; the cessation being equally as important as the continuance of it. Anything preventing a current from passing on the line, is no more injurious than that which will not allow it to be interrupted. The portion of the current which can be broken, is all that any use is made of: all the escape is not only of no utility, but it is a real hindrance to an advantageous employment of that remaining on the line.

It sometimes happens that the operating table becomes wet, or is made of wood only partly seasoned, so that a portion of the main current finds a passage through the moisture of the table while the key on it is open. This does not conduct any of the current to the earth, and cannot, therefore, be properly called an escape, though *every* relay in circuit with a key on a moist table, must have a high adjustment to receive the writing from such key. This trouble, however, does not in the least interfere with such office in receiving from other stations, nor does it at all affect other offices in working with one another.

CROSSES.

Another annoyance of very frequent occurrence on some lines having two or more wires on the same poles, are "crosses" or contact of the different line wires with each other, which, so far as their utility is concerned, reduces to *one* wire all the wires thus joined. Each wire crossed acts as a long ground wire to the others in contact with it. Suppose two wires, designated by Nos. 1 and 2, running on the same poles from New York to Washington, to be twisted together between Philadelphia and Baltimore. Next suppose No. 1 to be left open in New York, and No. 2 in Washington. Now, commencing at New York on No. 2, which is closed, and tracing southward over this wire until the cross is reached, and from that point over No. 1 to the southern terminus, we find a complete circuit, though both wires are open; consequently, Washington and Baltimore on No. 1, can work with Philadelphia and New York on No. 2. If Washington keeps both wires closed, New

York or Philadelphia can operate ooth wires south of the cross, by leaving either wire open and writing on the other; because the one wire north of the cross becomes a common conductor for both south of it. This is one mode for detecting and locating a cross. Another method is for New York to ask Philadelphia to try him on No. 2, with No. 1 open, while New York, doing just the reverse, tries Philadelphia on No. 1, with No. 2 open; and if they can work with each other on different wires, it shows those wires to be crossed between them. If they cannot get each other, New York tries the same thing with Baltimore, and so on until he gets to an office with which he can work on a different wire. This test determines the cross to be between such office and the first one from that station towards New York. When several wires become tangled, and at different places on the line, the task of locating becomes much more lengthy and difficult, on account of first getting the different offices to test with.

If, instead of opening one wire, New York or Philadelphia should try to work one of them with the other closed, he would operate only that one wire north of the cross, for the other wire north and the two south of it would still form a perfect circuit. The same principle holds true for any number of wires so joined: all but one being useless so long as they remain together, or at least between the two offices nearest the cross, and between which the cross is situated. In case of a cross of two wires between Philadelphia and Baltimore, it is necessary to leave one of them open only between these two cities. These offices may open No. 2, so that New York and Washington may communicate over No. 1. Then Philadelphia may put his ground wire on No. 2, leaving it open south of the ground, and work with New York, while Baltimore, in a similar manner, communicates with Washington.

REVERSED CURRENTS.

If on a line from New York to Washington two main batteries be placed, with both positive or both negative poles connected with the earth, no current will pass over the line,

though the circuit is complete; for each battery will oppose the other, stopping all galvanic action. With the batteries thus located, let Philadelphia or Baltimore put his ground wire on in either direction, and he will get a current; for the ground wire divides the line into two distinct circuits, each of which will operate without interfering with the other. This is the only case in which there can be a current *each* way with a ground wire on, and *no* current with it off.

An intermediate station wishing to connect a main battery to the line, first finds out from some office already having one, the direction of the poles of his battery; but the same thing may be determined in other ways.

When the current from a powerful battery is passed through the arms of an individual, a greater shock is experienced in the arm connected directly with the zinc or negative pole, than in the other.

If a circuit be opened and both ends of the break dipped into water, decomposition of the water will ensue, and the greatest volume of gas will rise from the wire leading directly to the negative pole. Therefore, the positive pole of another battery required to be put in circuit, must be connected to the wire giving the greatest shock, or evolving the most gas.

ADJUSTMENT AND CARE OF INSTRUMENTS.

The distance through which the armature of the relay should move, is very small; say equal to once the thickness of good writing paper. Magnets always retain more or less attraction, even when the circuit is perfectly broken, so that the spring on the armature must always have some tension, and a great deal more during a humid atmosphere, than while the air is clear and dry. This tempering of the relay spring according to the amount of magnetism while a key is open, is *adjusting;* and it is *high* or *low*, as the force of the spring is great or small. *This duty is the most important one connected with the management of instruments.* It not only wants to be done several times a day under the most favorable circumstances, but, from a few times daily, the frequency increases until the operator must keep hold of

the screw, *s*, Fig. 5, regulating the spring, turning first one way and then the other, nearly all the time he is either sending or receiving. Sometimes the slightest variation from a certain point, in either direction, will cause the instrument to cease working. Under such circumstances, adjusting is very difficult; but in a large majority of instances it requires only the memory and the will to do it. The tempering of the relay spring is also perplexing, as well as is the location of the trouble difficult, when a cross or an escape is a "swinging" one; that is, when a wire keeps swinging against another or against a tree, but remaining in contact only a short time.

Thunder-storms vary the current over a line so suddenly and to such a degree, as to cause the most difficult adjustment, at times rendering transmission utterly impossible. besides endangering the wire of the relay magnet, which is sometimes burned with a flash accompanied by a sharp report.

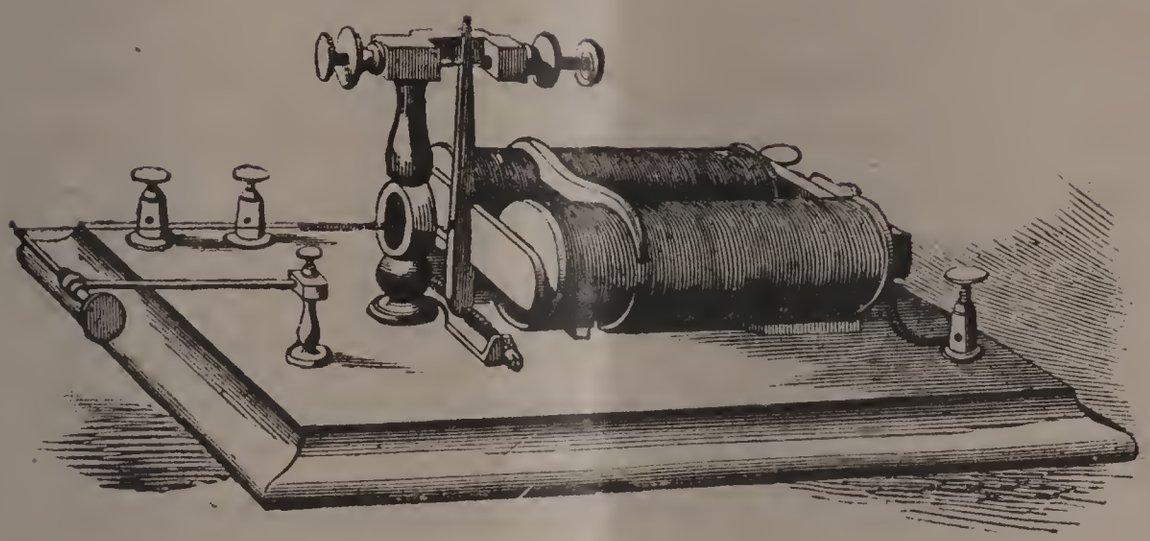
The Aurora Borealis sometimes influences the wire in a similar manner, but less violently, never causing any harm other than a suspension of business. Several forms of *lightning arresters* have been made and used for conducting atmospheric electricity from the line to the earth. It matters but little whether it is led to the ground or not, if it is only diverted from the relay magnet. Every operator can make one of two pieces of wire and a vial of water. A short piece of wire (six inches long) considerably larger than that in the relay magnet, run from each main circuit binding-screw of the relay, and the ends dipped into a small bottle of water, forms one of the best protections against lightning. The distance of the wires from each other in the water, as also their depth in it, may be varied, but they must not be allowed to come together. Water being a poor conductor of galvanic electricity, only a small portion of the current will pass through it, the larger part choosing the magnet wire; but atmospheric electricity, being possessed of enormous intensity, prefers the short water route. None of these devices, however, are an absolute safeguard, but during a severe thunder storm relays should be disconnected from the line, and in such a manner as to leave no break in the main circuit.

The local circuit, being confined to the office, is subject to none of the fluctuations of the main. The local battery simply grows weak by use, when it has to be renewed. The spring on the arm of the local (sounder or register) magnet, merely requires weakening, as the battery working it becomes exhausted. The iron part of this arm must never come so near the poles of the magnet that one thickness of ordinary writing paper will not pass between them. If permitted to touch, the magnet discharges slowly. The same truth applies to the relay magnet and its armature.

The platinum points of the key, and more frequently those of the armature of the relay, burned and roughened by the current, sometimes fail to break circuit. The remedy is to rub them gently with a very fine file, or draw between them a slip of clean paper.

If a relay "sticks," (fails to break circuit) it troubles only the office where that relay is located. If a key sticks, it interferes with both sender and receiver.

SMITH'S MANUAL



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